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STATUS OF THE DEVELOPMENT OF A LONG-LIFE ENGINE COOLANT
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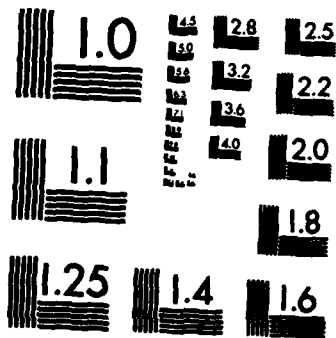
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STATUS OF THE DEVELOPMENT OF A LONG-LIFE
ENGINE COOLANT SYSTEM

November 1983

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United States Army
Belvoir Research & Development Center
Fort Belvoir, Virginia 22060

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| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The objective of this study is to evaluate two prototype long-life coolant systems in actual vehicle tests. The systems utilize an electronic coolant condition sensor in conjunction with either the newly developed MIL-A-53009 Extender Additive or a commercial spin-on filter/conditioner unit. Both systems were started with an antifreeze with a partially depleted inhibitor system. Results show that, to date, there has been no apparent depletion of the additive systems in either vehicle, and the sensors are functioning properly. | | |

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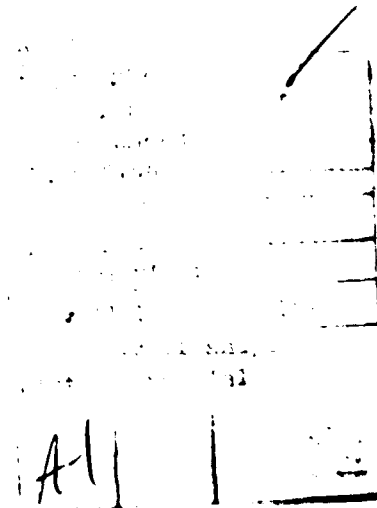
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STATUS OF THE DEVELOPMENT OF A LONG-LIFE COOLANT SYSTEM

I. BACKGROUND

The advent of the 1973 energy crisis resulted in investigations directed toward reclaiming used antifreeze. One study, described in MERADCOM Report 2166,¹ shows that it is possible to reclaim used antifreeze. A second study, MERADCOM Report 2265,² describes an antifreeze extender package that is simply added, in solution, to a used and marginal antifreeze to reinhibit the coolant and prevent corrosion. A new Military Specification covering this material, MIL-A-53009,³ has been issued. During this same period, industry developed a spin-on-type filter/conditioner based on a solid extender additive package, which was successfully tested in simulated service tests with military antifreeze. Both approaches adequately reinhibit the coolant and prevent corrosion of cooling system metals. However, the filter/conditioner approach requires hardware additions; the additive method specified in MIL-A-53009 does not.

Recent developments in solid state electronics have made it possible to develop a coolant condition sensor,⁴ one which will indicate when a coolant's inhibitor system has been depleted to the point where the coolant should be replaced or reinhibited before any significant corrosion of the cooling system metals has taken place. The military standard antifreeze, MIL-A-46153,⁵ contains inhibitors that are considered anodic-type inhibitors. Those anions present form passive films on the metal surfaces and thereby retard further corrosion. The measurement technique requires a dual electrode system (sensing and reference) and provides an indirect measurement of coolant corrosivity. As the inhibitors become depleted in the coolant the potential of a steel or an aluminum electrode would shift towards more negative values. In practice the reference is silver and the sensing electrode consists of steel electrically shorted to aluminum to form a galvanic couple for increased sensitivity. The electrometer is capable of measuring the *in-situ* potential of the sensing electrode versus a reference electrode which in turn activates a warning device, such as a light-emitting diode (LED), when the potential difference exceeds a preset value.

The combination of the new inhibitor additive technology with the electronic coolant condition sensor unit has resulted in the development of two prototype long-life coolant systems. Both systems utilize the electronic sensor in operating vehicles. In one system, the MIL-A-53009 extender package is used for re-inhibition; in the other system, the commercial spin-on filter/conditioner is used for the same purpose.

¹ James H. Conley and Robert G. Jamison, "Reclaiming Used Antifreeze," MERADCOM Report 2166, March 1976.

² James H. Conley and Robert G. Jamison, "Development of an Antifreeze Extender and Water Inhibitor for Automotive Cooling Systems," MERADCOM Report 2265, December 1978.

³ Military Specification, MIL-A-53009, "Additive, Antifreeze Extender, Liquid Cooling System," 25 January 1983.

⁴ Robert Baboian and Gardnew S. Haynes, "Detecting Coolant Corrosivity with Electrochemical Sensors," Presented at ASTM Committee D-15 Symposium on State of the Art in Engine Coolant Testing, 10 April 1979.

⁵ Military Specification, MIL-A-46153, "Antifreeze, Ethylene Glycol, Inhibited, Heavy Duty, Single Package," 31 July 1979.

II. DETAILS OF TEST

Approximately 10 gallons of used antifreeze was collected from vehicles in the field. The antifreeze was tested with the MIL-T-36812 Reserve Alkalinity Test Kit⁶ and showed that the antifreeze was "marginal" which indicates low inhibitor level.

Two vehicles were selected as the test vehicles, a 1/4-ton Jeep and a 1-1/4-ton truck. Both vehicles were fitted with an electronic coolant condition sensor with the warning light installed on the dashboard inside the driver's compartment. It was necessary to modify the electrical circuit since the sensor operates on 12-V d.c.; the military vehicles operate on a 24-V d.c. system.

Both vehicles were charged with the used antifreeze and an initial sample was taken for test of pH and reserve alkalinity (RA). MIL-A-53009 additive was added to the 1/4-ton Jeep cooling system at a rate of three volume percent based on the total system volume. The commercial spin-on filter/conditioner unit was installed on the 1-1/4-ton truck in a by-pass mode. Every month thereafter a small sample was removed from each vehicle and the tests were repeated in the laboratory for pH and RA values.

Block diagrams of the two prototype systems are shown in Figures 1 and 2. Each system is set up to indicate when the inhibitor level is low by activation of a red warning light mounted on the vehicle instrument panel.

III. RESULTS OF TESTS

Results of the tests are shown in Tables 1 and 2. The data clearly show that after re-inhibition, the pH and reserve alkalinity values are at acceptable levels and have remained so for the entire test period. Slight variations in the values are attributed to the fact that samples have been removed and the volume of coolant readjusted.

Comparison of the mileage and hours of operation shows that the vehicles are at idle a considerable percent of the total operating time. Engine operation under idling conditions is considerably more taxing to the coolant than is continued running.

Both prototype systems are operating properly including the coolant condition sensors. The red warning lights come on when the vehicles are first started and go out immediately and remains out as they should if the inhibitor level is adequate.

⁶ Military Specification, MIL-T-36812, "Test Kit, Reserve Alkalinity, Antifreeze," 6 June 1972.

IV. CONCLUSIONS

Since the reserve alkalinity values of both systems have remained fairly high over the test period, it is evident that the test will have to be continued until the inhibitors in both systems have been depleted to that point where the warning lights are activated in order to determine if the total system, sensor, and re-inhibitor, perform adequately.

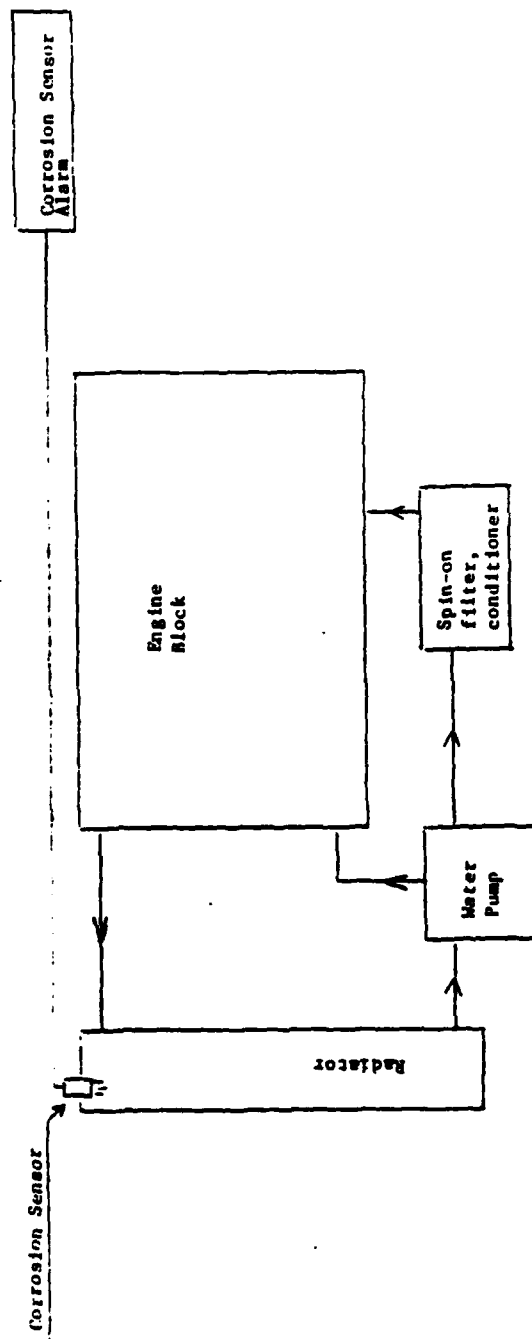


Figure 1. Long-life coolant system schematic for 1/4-ton jeep.

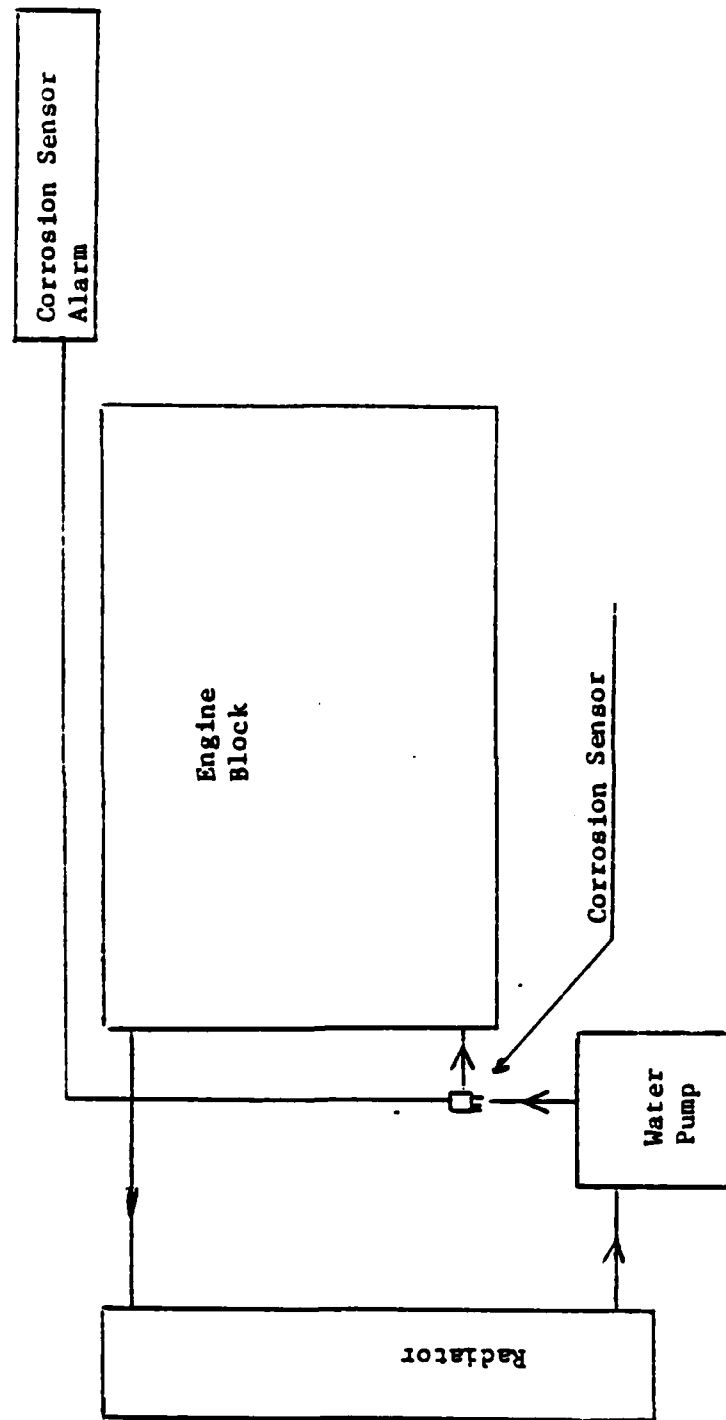


Figure 2. Long-life coolant system schematic for 1-1/4-ton truck.

Table 1. 1/4-Ton Jeep Test Results

| Month | pH | Reserve Alkalinity | Total Miles | Total Hours |
|-------|------|--------------------|-------------|-------------|
| 1 | 6.8* | 12.7* | 0 | 0 |
| 1 | 8.0 | 21.4 | 84.4 | 7.2 |
| 2 | 8.0 | 21.3 | 168.2 | 19.8 |
| 3 | 8.0 | 21.6 | 272.2 | 44.1 |
| 4 | 8.0 | 20.2 | 353.2 | 59.5 |
| 5 | 8.0 | 20.5 | 406.8 | 61.3 |
| 6 | 7.8 | 20.5 | 455.9 | 66.8 |
| 7 | 8.1 | 21.0 | 508.9 | 77.9 |
| 8 | 8.1 | 21.7 | 593.0 | 87.9 |
| 9 | 8.0 | 21.2 | 722.0 | 93.3 |
| 10 | 8.0 | 21.6 | 860.4 | 151.9 |
| 11 | 8.0 | 21.7 | 1028.5 | 210.8 |

* Initial fill values without extender additive.

Table 2. 1 1/4-Ton Truck Test Results

| Month | pH | Reserve Alkalinity | Total Miles | Total Hours |
|-------|------|--------------------|-------------|-------------|
| 1 | 6.8* | 12.5* | 0 | 0 |
| 1 | 7.8 | 20.4 | 32.0 | |
| 2 | 7.9 | 20.5 | 308.4 | 17.7 |
| 3 | 7.8 | 20.0 | 434.4 | 35.7 |
| 4 | 8.0 | 20.1 | 623.4 | 96.7 |
| 5 | 7.8 | 20.0 | 762.4 | 119.6 |
| 6 | 7.8 | 20.0 | 970.2 | 142.5 |
| 7 | 7.8 | 20.0 | 1145.2 | 160.3 |
| 8 | 7.8 | 20.0 | 1346.9 | 185.1 |
| 9 | 8.0 | 20.3 | 1490.7 | 197.4 |
| 10 | 8.1 | 21.9 | 1500.0 | 197.9 |
| 11 | 8.0 | 21.6 | 1735.8 | 216.2 |
| 12 | 8.0 | 21.4 | 2619.3 | 244.8 |
| 13 | 8.0 | 21.5 | 2691.3 | 256.5 |

* Initial GH values before installation of filter/conditioner.

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